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PRELIMINARY INVESTIGATION OF EFFECTS OF ALPHA-PARTICLE  
BOMBARDMENT ON THE CREEP RATE OF ALUMINUM

By J. Howard Kittel

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Flight Propulsion Research Laboratory  
Cleveland, Ohio

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## NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUMPRELIMINARY INVESTIGATION OF EFFECTS OF ALPHA-PARTICLE  
BOMBARDMENT ON THE CREEP RATE OF ALUMINUM

By J. Howard Kittel

## SUMMARY

A preliminary investigation was made to determine the effects of alpha-particle bombardment on the creep rate of aluminum wire at 400° F. The alpha radiation from an 85-millicurie polonium source appeared to decrease slightly the creep rate of the aluminum. A metallographic examination of the creep specimens showed no microstructural changes that could be attributed to the alpha-particle bombardment.

## INTRODUCTION

The fundamental research at the NACA Cleveland laboratory on the physical properties of materials includes a study of the mechanism of creep. As a part of this study a preliminary investigation was made to determine the effect of alpha-particle bombardment on the creep rate of a commercially pure polycrystalline metal, aluminum. Although the penetration of these particles in metals is small, they possess high energies. There is a possibility that these energies might be sufficient to affect the process of creep in polycrystalline metals. Work by Andrade (reference 1) indicated that, in the case of single crystals of cadmium, alpha radiation can increase creep rates as much as five times. No reference describing creep of polycrystalline metals under alpha-particle bombardment has been found in the literature.

Results from the preliminary investigation described in this paper are presented in the form of curves showing total elongations obtained for each specimen as a function of time. Results are also presented from a metallographic study made on the creep specimens to detect any changes in the microstructure that might have resulted from the alpha-particle bombardment.

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## APPARATUS AND PROCEDURE

Commercially pure aluminum wire was used for the creep investigation because of its availability and because its low density would enable greater penetration of the bombarding particles. The diameter of the wire, measured with a filar micrometer, was  $0.01014 \pm 0.00002$  inch. The alpha-particle source was 85 millicuries of polonium plated on a foil that was bent into a U-shape and placed at a radial distance of 2 millimeters from the specimen. Radioactive decay of the polonium decreased its activity to 80 millicuries during the time required for the experiments. The length of the foil was 25 millimeters, which was sufficient to irradiate uniformly the 20-millimeter gage length of the specimen. Previous work showed that the presence of a foil about the specimen slightly decreased its creep rate. This effect probably resulted from a slight difference in temperature of the specimen caused by prevention of heat absorption by the foil from the walls of the furnace. In order to remove the effect of this variable, the nonirradiated creep specimens were surrounded with a foil of dimensions and reflectivity similar to those of the radioactive foil.

In order to remove the effects of any previous cold-working, all specimens were simultaneously annealed at  $675^{\circ}\text{F}$  for 15 minutes before being stressed. The creep determinations were made at an ambient-air temperature of  $400^{\circ} \pm 2^{\circ}\text{F}$  measured by a thermocouple immediately adjacent to the specimen. According to reference 2 (p. 200), this temperature is about  $100^{\circ}\text{F}$  above the recrystallization temperature of aluminum. In order to obtain a uniform specimen temperature, and to maintain complete accessibility of the specimen during testing, a furnace with a circulating atmosphere was used (fig. 1). The variation in ambient temperature along the gage length of the specimen was less than  $\pm 1.5^{\circ}\text{F}$ . Measurements of the distance between gage marks on the specimen were made through a glass window in the furnace by means of a telescope mounted on a micrometer slide that could be read to 0.001 millimeter. The specimens were stressed to 2910 pounds per square inch by a directly suspended weight.

A metallographic study was made of specimens after the annealing operation, after being stressed under alpha radiation, and after being stressed without alpha radiation.

## RESULTS AND DISCUSSION

The results of eight creep determinations, made in the order indicated by the test number, are shown in figure 2. Elongation

data are given for four specimens subjected to alpha-particle bombardment during testing and for four specimens that were not irradiated. It can be noted that the elongations of specimens not subjected to radiation tend to be somewhat greater than those of specimens that were irradiated, although much overlapping of the data is apparent, particularly at the longer periods of time.

Second-stage (approximately constant-rate) creep predominated in the tests during the interval between 20 and 90 minutes test time. After 90 minutes, third-stage (increasing-rate) creep and rupture of the specimens occurred. No creep determinations were made beyond 180 minutes. The creep rates of the eight specimens during the period of second-stage creep are given in the following table.

With alpha radiation		Without alpha radiation	
Test	Creep rate (percent/ min)	Test	Creep rate (percent/ min)
1	0.065	2	0.085
4	.070	3	.073
7	.083	5	.075
8	.064	6	.076
Average	.071	Average	.077

The average second-stage creep rate of the four specimens subjected to alpha-particle bombardment was 0.071 percent per minute; whereas the average second-stage creep rate of the four nonirradiated specimens was 0.077 percent per minute or about 8 percent greater. On the basis of results obtained in this preliminary investigation, it appears that alpha-particle bombardment might have very slightly decreased the creep rate of the aluminum wire. Great significance, however, should not be given to these results because of the limited number of experiments.

As was previously mentioned, determinations of the effect of alpha radiation on the creep rate of single crystals of cadmium have shown an accelerating effect (reference 1). It appears therefore that the effects of alpha-particle bombardment on creep rates of materials may depend upon the nature of the material and upon the number of crystals in the test section.

The metallographic examinations of the specimens showed no changes in the microstructure that could be attributed to the alpha radiation.

# SUMMARY OF RESULTS

The following results were noted in determinations of the creep rates of aluminum wire with and without alpha-particle bombardment:

1. Alpha-particle bombardment from an 85-millicurie polonium source appeared to decrease slightly the creep rate of polycrystalline aluminum wire at 400° F.

2. No metallographic changes were noted in the aluminum specimens that could be attributed to the alpha-particle bombardment.

Flight Propulsion Research Laboratory,  
National Advisory Committee for Aeronautics,  
Cleveland, Ohio

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## REFERENCES

1. Andrade, E. N. da C.: Effect of Alpha-Ray Bombardment on Glide in Metal Single Crystals. Nature, vol. 156, no. 3952, July 28, 1945, pp. 113-114.
2. Archer, R. S.: Heat Treatment of Metals. Metals Handbook, Am. Soc. Metals (Cleveland), 1939 ed., pp. 198-206.

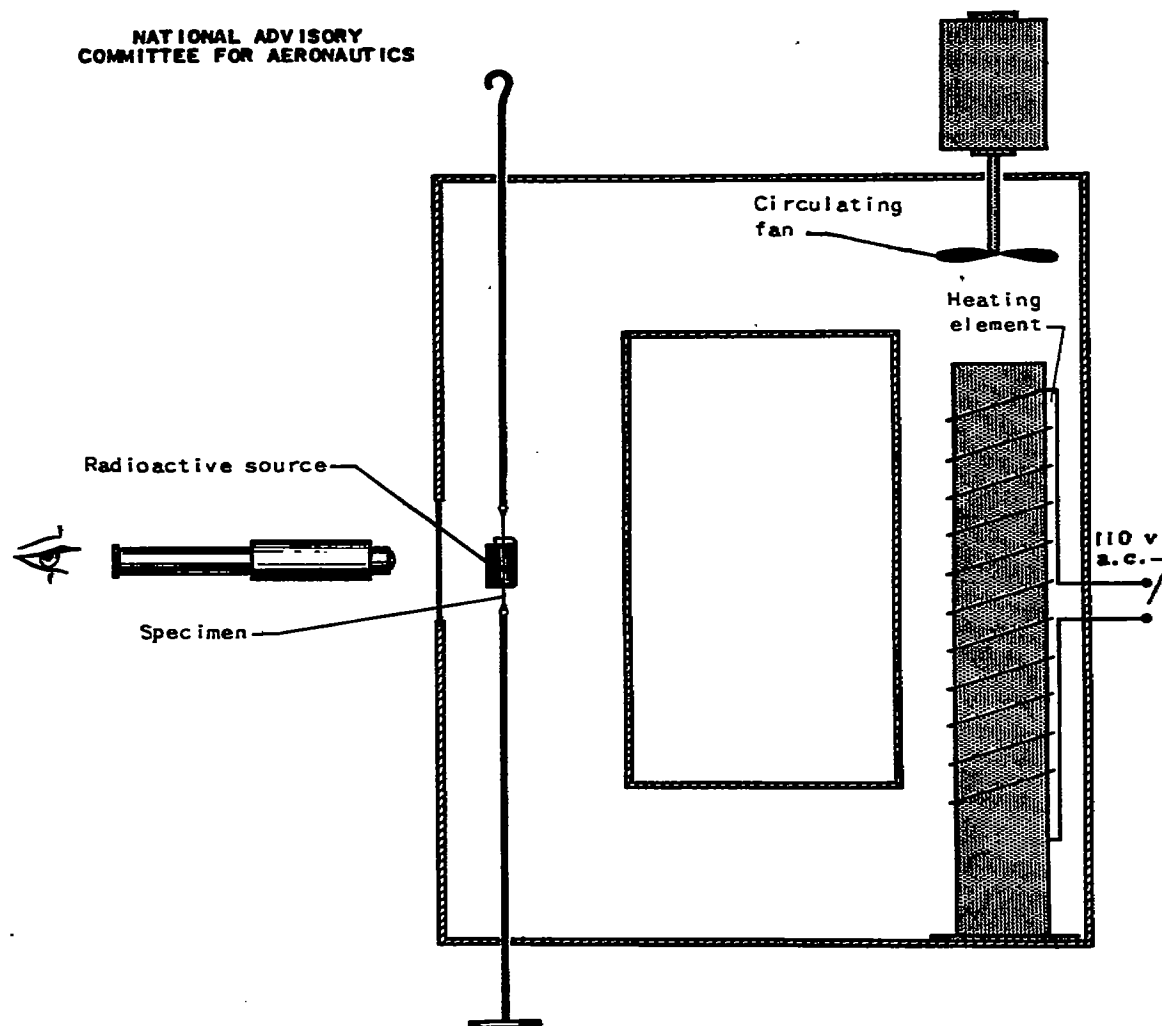


Figure 1. - Furnace used for creep-rate observations on aluminum wire at 400° F. The furnace utilizes an atmosphere moving in a closed circuit to obtain uniform specimen temperature and maximum accessibility of the specimen.



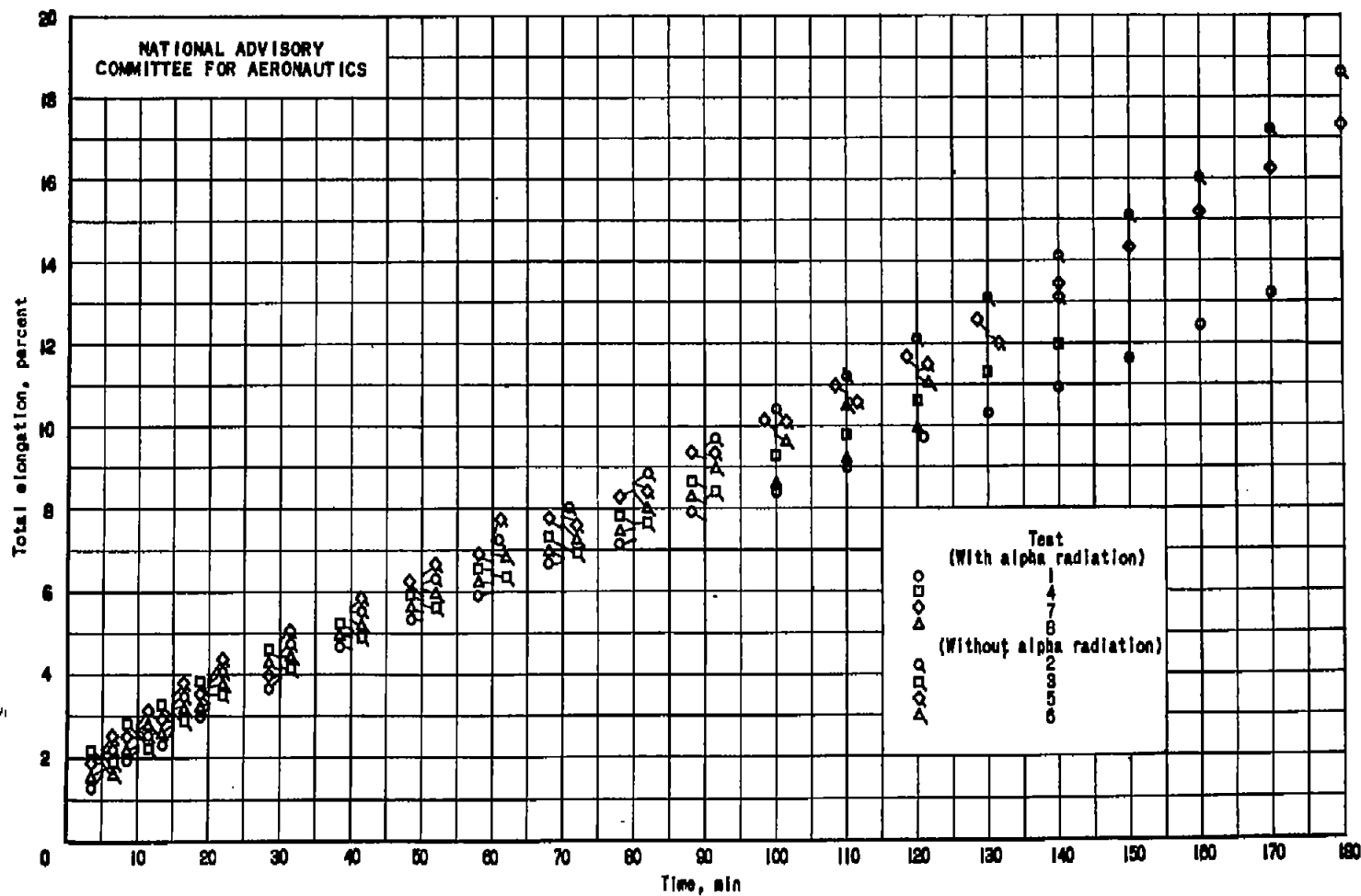


Figure 2. - Creep curves for eight aluminum specimens stressed at 2010 pounds per square inch at 400° F.